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SYSTEMATIC REVIEW

Probiotics and chronic inflammatory skin diseases

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ABSTRACT

It is well established that probiotics exert beneficial effects on human health. Their use in prophylaxis and therapy, particularly in inflammatory diseases of the gastrointestinal tract, is undisputed. Moreover, studies from recent years indicate that the administration of probiotics in dentistry is advisable, particularly in dental caries and in chronic periodontitis in adults. In this study, the available data on the potential application of oral and topical probiotics, including their mechanisms of action, in dermatological therapy were analyzed. The present review focuses on the effects of oral and topical probiotics in chronic skin diseases, emphasizing their role in the management of atopic dermatitis, acne vulgaris, rosacea, and psoriasis.

Keywords: probiotics, atopic dermatitis, acne vulgaris, rosacea, psoriasis.

The skin of a healthy individual constitutes a barrier protecting the body against microbial invasion and infection. This protection is determined by the normal anatomy and physiology of the skin, as well as its colonization, primarily by nonpathogenic bacteria. These are resident microorganisms that normally grow on or within the skin, remaining more or less constant. Colonization of the skin by resident microorganisms represents physiological colonization, occurring at densities of approximately 10^4–10^5 bacteria/cm² [1]. Resident bacteria typically include aerobic genera such as *Staphylococcus* (including *S. epidermidis* and *S. hominis*), *Corynebacterium* (aerobic coryneforms), *Micrococcus*, and anaerobic species such as *Propionibacterium acnes* (formerly *Cutibacterium acnes*). The latter is ordinarily a harmless resident but may incite or contribute to the condition known as acne [2].

Other microorganisms, usually present only temporarily on the skin, are classified as transients and may include streptococci, enterococci, enterobacteria, pseudomonads, and others. Physiological colonization reduces the risk of

infections and skin diseases by preventing pathological colonization, which results from the adherence of pathogenic microorganisms to skin cells [3]. Moreover, some *Staphylococcus* species, particularly *Staphylococcus epidermidis* and *Staphylococcus hominis*, can produce commensal-derived antimicrobial peptides (AMPs), such as phenol-soluble modulins and lantibiotics. These peptides exert antimicrobial activity and act synergistically with host-derived AMPs, such as cathelicidin IL-37, to inhibit the survival of skin pathogens [4,5]. Thus, the physiologic (normal) microbiota of the skin, along with the AMPs produced by its constituent bacteria, provides the first line of defense against microbial pathogens. A reduction in the number of resident microorganisms on the skin often results from personal hygiene practices or treatment with antiseptics. However, the normal microbiota can be rapidly restored owing to the active growth of the remaining viable resident bacteria.

It is well established that probiotics can help maintain a healthy balance of the intestinal flora and stabilize the intestinal epithelial cell barrier. In line with the current WHO definition [6], probiotics are living microorganisms which, when consumed in adequate amounts, exert beneficial health effects independently of basic nutrition. Moreover, this definition is supplemented by specific criteria: a probiotic agent should neither be pathogenic nor toxic to the human body, and it should not induce immune disturbances. Thus, a probiotic strain should have GRAS (Generally Recognized As Safe) status, and the safety of its application should be supported by both *in vitro* and *in vivo* studies [7]. Probiotic strains include mainly lactic acid bacilli of the *Lactobacillus* and *Bifidobacterium* genera, as well as *Saccharomyces boulardii* yeasts. Oral administration of probiotics in prophylaxis and therapy, particularly for gastrointestinal diseases (including antibiotic-associated diarrhea), is no longer questioned [8,9].

Probiotics help maintain a healthy balance of intestinal flora, stabilize the mucosal barrier, and promote mucin secretion, thereby preventing colonization of pathogens within the epithelium. Pathogen inhibition is mediated through two distinct mechanisms [5,10,11]. The first is a component of the physical defense system, which directly prevents pathological colonization by limiting the available space for pathogens. It should be emphasized that some probiotics are capable of effectively colonizing the skin [12].

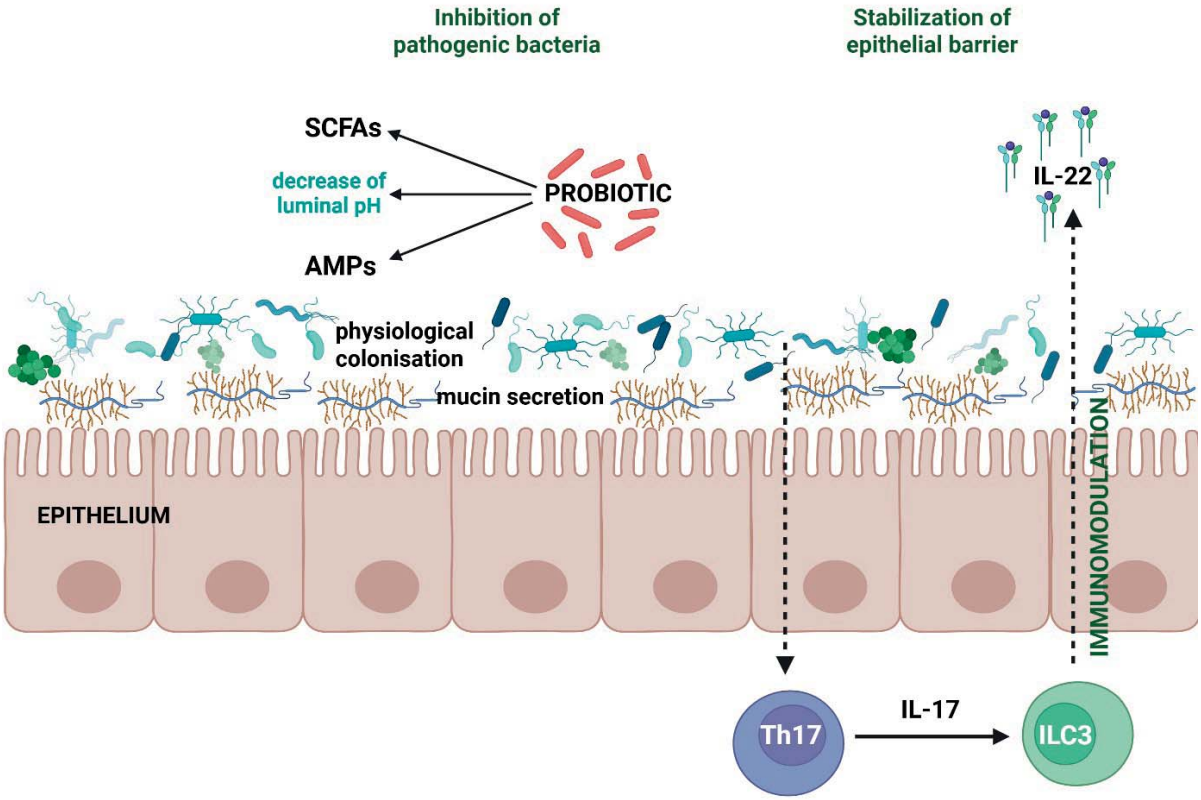
The second mechanism is associated with the antagonistic properties of probiotics, primarily resulting from the production of short-chain fatty acids (SCFAs) and lactic acid, as well as the synthesis of antimicrobial peptides (AMPs). These compounds may directly inhibit the growth of, or inactivate, pathogenic microorganisms [12].

The accumulation of high concentrations of SCFAs in the intestinal tract can rapidly decrease the pH, thereby inhibiting pathogen growth. Furthermore, certain probiotic strains have been shown to induce T helper 17 (Th17) cells, leading to the secretion of interleukin-17α (IL-17α), which subsequently stimulates type 3 innate lymphoid cells to produce interleukin-22 (IL-22). This cytokine plays an important role in maintaining intestinal homeostasis, promoting healing, and facilitating tissue regeneration. The effects of probiotics on the host are presented in **Figure 1**.

Moreover, in recent years, increasing evidence has pointed to the existence of a gut–skin axis, a relationship between intestinal microbiota and inflammatory skin diseases [13,14].

The antineoplastic activity of probiotic strains has also been analyzed [15]. *In vitro* studies have demonstrated that probiotics can induce tumor cell apoptosis and inhibit tumor cell proliferation and metastasis [16]. In a mouse cancer model, the use of a probiotic aerosol formulation with *Lactobacillus rhamnosus* GG was shown for the first time to play a beneficial role in preventing melanoma metastasis and in activating antitumor effector cells [17]. These findings suggest the potential of a novel strategy involving the administration of probiotics in spray form, which may be particularly useful in the treatment of skin diseases. Other studies in mouse models have reported that *Bifidobacterium bifidum* and *Lactobacillus acidophilus* can be used as biotherapeutic agents to inhibit colon cancer by modulating intestinal microbiota [18].

Recent research has also demonstrated that probiotics are useful as supplementary preparations in dentistry. Probiotics containing hydrogen-peroxide–producing *Lactobacillus* species may exert antagonistic effects against cariopathogens and periopathogens, thereby reducing the initiation of the cariogenic process and the progression of chronic periodontitis [19]. In my own research, I demonstrated that probiotic tablets containing the *Lactobacillus reuteri* strain significantly improved clinical parameters and reduced proinflammatory cytokine levels



▲ Figure 1. The effects of probiotics on the host (SCFAs- shot chain fatty acids, AMPs- antimicrobial peptides, Th17- T helper cells 17, ILC3- Type 3 innate lymphocyte) created with BioRender.com.

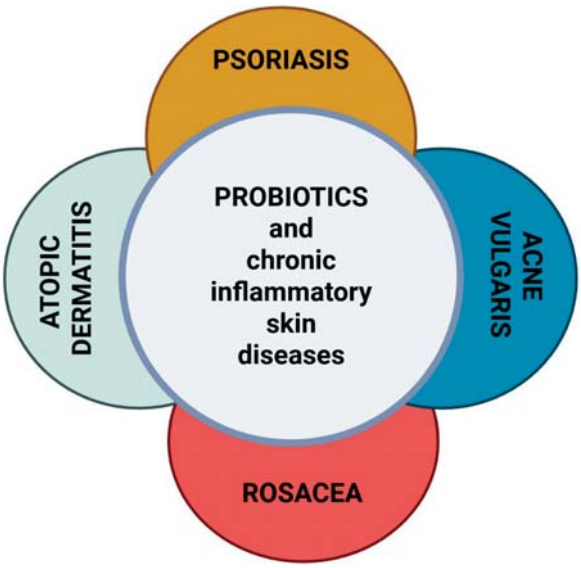
in patients with moderate chronic periodontitis [20]. The results of these and other studies justify the implementation of novel strategies for the use of probiotics in oral diseases [19].

In dermatology, oral and topical probiotics are used in the treatment of inflammatory skin diseases, as shown **Figure 2** [5,13].

The aim of this study was to analyze the beneficial effects of probiotics in skin diseases, including atopic dermatitis, acne vulgaris, rosacea, and psoriasis. Moreover, it was considered appropriate to present current concepts regarding the anti-inflammatory mechanisms of action of probiotics, particularly in inflammatory skin diseases.

Atopic dermatitis (AD) is a genetically determined chronic inflammatory skin disease associated with significant dysfunction of both the epidermal and intestinal barriers, induction of chronic skin inflammation, and alterations in microbiota composition [13,21]. *Staphylococcus aureus* is the most common pathogenic bacterium, dominating on the skin of AD patients, whereas *Staphylococcus epidermidis* and *Corynebacterium* spp. are markedly depleted. Numerous studies have demonstrated the beneficial effects of oral probiotics on the clinical symptoms of patients with AD. The oral probiotics used most frequently contain strains such as *Lactobacillus bulgaricus*, *Lactobacillus casei*, *Lactobacillus paracasei*, *Lactobacillus helveticus*, *Lactobacillus plantarum*, *Lactobacillus rhamnosus*, *Bifidobacterium bifidum*, and *Bifidobacterium adolescentis* [22,23].

Acne vulgaris (AV) is a chronic skin disease with periods of exacerbation, most commonly affecting young individuals. It is associated with hyperactivity of the sebaceous glands and is characterized by the formation of non-inflammatory comedones or inflammatory pustules, located primarily on the face and back, along with increased levels of proinflammatory cytokines in the skin [24]. A large volume of sebum accumulating within the sebaceous glands, together with the presence of *Cutibacterium acnes* in the pilosebaceous canal, may play a causal role



▲ Figure 2. Probiotics and chronic skin diseases.

in AV [24]. This anaerobic bacterium produces lipase enzymes that hydrolyze sebum triglycerides into free fatty acids. These compounds are particularly irritating, as they can penetrate into the dermis and promote inflammation. Moreover, recent studies suggest a role for insulin and insulin-like growth factor (IGF-1) in the pathogenesis of AV [25]. Their increased production, associated with a high-carbohydrate diet, may promote the proliferation of sebocytes and keratinocytes, as well as induce lipid synthesis in the sebaceous glands [24]. Additionally, gut dysbiosis may contribute to increased IGF-1 levels [12,26]. Considering these mechanisms, the contribution of the gut–skin axis in the pathogenesis of AV has been proposed [12]. Supporting this hypothesis, clinical data have demonstrated that oral administration of *Lactobacillus rhamnosus* for 12 weeks reduced IGF-1 secretion in the skin and improved AV symptoms [27]. Significant reductions in AV lesion counts have also been observed with other oral probiotics, including combinations of *Lactobacillus acidophilus*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, and *Bifidobacterium bifidum*, as well as with *Escherichia coli* Nissle and *Lactobacillus. plantarum* probiotic preparations [28].

Additionally, it has been indicated that some probiotics can persist and successfully colonize the skin, inducing keratinocytes and sebocytes to produce antimicrobial peptides (AMPs) or other metabolites that may directly inhibit or kill pathogens. Considering the above, as well as the markedly increasing use of topical probiotics in skin diseases over the past two decades, randomized controlled trials and clinical investigations were conducted between 2009 and 2024 to examine probiotics for AV treatment [29]. These studies analyzed topical probiotics containing bacterial strains such as *Lactobacillus acidophilus*, *Lactobacillus salivarius*, *Lactobacillus plantarum*, *Lactobacillus paracasei*, *Enterococcus faecalis*, and *Bifidobacterium animalis*. Treatment durations varied, ranging from 4 to 12 weeks. The findings demonstrated that *Lactobacillus* strains, particularly *Lactobacillus plantarum*, significantly reduced acne-related inflammation directly at the site of application and enhanced the healing process [28].

Another chronic inflammatory skin disease with periods of exacerbation is rosacea, characterized by erythema, papules, and pustules, predominantly on the face [29]. The condition occurs in both men and women, with onset usually after the third decade of life. The pathogenesis of rosacea remains unclear, but genetic factors, an abnormal innate immune response, and alterations in the skin microbiota are recognized as contributors [30]. Although microorganisms may not be the central causative agents, emerging evidence suggests that skin dysbiosis, acting as a potentiator of inflammation or as a trigger factor, contributes to disease progression. The colonization of the skin by *Demodex folliculorum* mites, together with their associated bacteria such as *Bacillus oleronius*, has been impli-

cated in the pathogenesis of rosacea [5,31]. This microbial presence has the potential to activate Toll-like receptor 2 (TLR2), thereby exacerbating the inflammatory process characteristic of rosacea [32]. Gut dysbiosis, within the framework of the gut–skin axis, is also thought to play a role in rosacea. In particular, *Helicobacter pylori* infection and small intestinal bacterial overgrowth (SIBO) have been associated with disease development [33]. The eradication of SIBO has been shown to improve rosacea symptoms. These findings provide a rationale for the use of oral probiotics in this condition, as they promote a healthier microbial balance, which may help reduce systemic inflammation and improve skin condition. Reports to date document that oral administration of probiotics such as *Escherichia coli* Nissle, certain strains of *Lactobacillus*, *Bifidobacterium*, and *Saccharomyces* has been associated with more frequent clinical remission and symptomatic improvement in patients with rosacea [32].

Moreover, topical probiotics are suggested to have anti-inflammatory activity, strengthening skin barrier function, directly enhancing its properties, and locally modulating the immune response [32]. However, the use of probiotics in the treatment of rosacea remains relatively limited. Further clinical trials employing both oral and topical probiotics are therefore necessary to assess the long-term therapeutic outcomes.

Another chronic and relapsing immune-mediated inflammatory skin disease is psoriasis. This condition often occurs within families and has a hereditary component. Psoriatic lesions are characterized by keratinocyte hyperproliferation, resulting in marked keratinocyte hyperplasia [34]. Despite advances in systemic pharmacological therapies, the long-term management of psoriasis remains ineffective. Analysis of psoriasis pathogenesis has revealed its frequent coexistence with gastrointestinal diseases, such as inflammatory bowel disease (IBD) and also gut dysbiosis [12,20]. Through the bidirectional interaction between the gut and skin, the gut–skin axis may exacerbate systemic inflammation by promoting the release of proinflammatory cytokines [12]. Considering the potential role of gut microbiota modulation, probiotics have emerged as a novel therapeutic approach in psoriasis management. In randomized clinical trials conducted to date in adults, oral administration of multi-strain probiotics (*Lactobacillus acidophilus*, *Bifidobacterium bifidum*, *Bifidobacterium lactis*, *Bifidobacterium longum*) or a single strain (*Lactobacillus rhamnosus*) has been investigated [35]. These studies demonstrated that probiotic treatment in patients with psoriasis reduces inflammation, improving outcomes measured by the Psoriasis Area and Severity Index (PASI) and the Dermatology Life Quality Index (DLQI), while also contributing to the restoration of skin health [35]. However, further research in this area is necessary, particularly with consideration of an integrated strategy combining probiotics with conventional psoriasis therapy.

Summary

In summary, this study presents data indicating that probiotics may be useful in the management of chronic bacterial infections. Oral probiotics help maintain a healthy intestinal flora and reduce systemic inflammation, while topical probiotics can directly alleviate local inflammation. The application of both oral and topical probiotics represents a novel approach for the treatment of chronic inflammatory skin diseases, including atopic dermatitis, acne vulgaris, rosacea, and psoriasis. The administration of both oral and topical probiotics constitutes a novel therapeutic strategy for chronic inflammatory skin diseases, including atopic dermatitis, acne vulgaris, rosacea, and psoriasis, which frequently involve facial skin. Probiotics confer beneficial effects on skin health by modulating inflammatory pathways and improving facial aesthetics.

Declarations

Conflict of interest statement
The authors declares no conflict of interest.

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References

1. Cogen AL, Nizet V, Gallo RL. Skin microbiota: a source of disease or defence? Br J Dermatol. 2008;158(3):442-455. doi: 10.1111/j.1365-2133.2008.08437.x.
2. Dréno B, Pécastaings S, Corvec S, Veraldi S, Khammari A, Roques C. Cutibacterium acnes (Propionibacterium acnes) and acne vulgaris: a brief look at the latest updates. J Eur Acad Dermatol Venereol. 2018;32 Suppl 2:5-14. doi: 10.1111/jdv.15043.
3. Elsner P. Antimicrobials and the skin physiological and pathological flora. Curr Probl Dermatol. 2006;33:35-41. doi: 10.1159/000093929.
4. Nakatsuji T, Chen TH, Narala S, Chun KA, Two AM, Yun T, et al. Antimicrobials from human skin commensal bacteria protect against Staphy-

lococcus aureus and are deficient in atopic dermatitis. Sci Transl Med. 2017;9(378):aah4680. doi: 10.1126/scitranslmed.aah4680.
5. De Almeida CV, Antiga E, Lulli M. Oral and topical probiotics and postbiotics in skincare and dermatological therapy: a concise review. Microorganisms. 2023;11(6):1420. doi: 10.3390/microorganisms11061420.
6. Food and Agriculture Organization of the United Nations; World Health Organization. Guidelines for the evaluation of probiotics in food: report of a joint FAO/WHO Working Group on drafting guidelines for the evaluation of probiotics in food. London (ON): FAO/WHO; 2002.
7. Didari T, Solki S, Mozaffari S, Nikfar S, Abdollahi M. A systematic review of the safety of probiotics. Expert Opin Drug Saf. 2014;13(2):227-239. doi: 10.1517/14740338.2014.872627.
8. Ritchie ML, Romanuk TN. A meta-analysis of probiotic efficacy for gastrointestinal diseases. PLoS One. 2012;7(4):e34938. doi: 10.1371/journal.pone.0034938.
9. Sanders ME, Merenstein DJ, Reid G, Gibson GR, Rastall RA. Probiotics and prebiotics in intestinal health and disease: from biology to the clinic. Nat Rev Gastroenterol Hepatol. 2019;16(10):605-616. doi: 10.1038/s41575-019-0173-3.
10. Hill C, Guarner F, Reid G, Gibson GR, Merenstein DJ, Pot B, et al. Expert consensus document: the International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. Nat Rev Gastroenterol Hepatol. 2014;11(8):506-514. doi: 10.1038/nrgastro.2014.66.
11. Kim SK, Guevarra RB, Kim YT, Kwon J, Kim H, Cho JH, et al. Role of probiotics in human gut microbiome-associated diseases. J Microbiol Biotechnol. 2019;29(9):1335-1340. doi: 10.4014/jmb.1906.06064.
12. Lizardo MP, Tavaria FK. Probiotic growth in skin-like conditions. AIMS Microbiol. 2022;8(4):388-402. doi: 10.3934/microbiol.2022027.
13. Szántó M, Dózsa A, Antal D, Szabó K, Kemény L, Bai P. Targeting the gut-skin axis-probiotics as new tools for skin disorder management? Exp Dermatol. 2019;28(11):1210-1218. doi: 10.1111/exd.14016.
14. Gao T, Wang X, Li Y, Ren F. The role of probiotics in skin health and related gut-skin axis: a review. Nutrients. 2023;15(14):3123. doi: 10.3390/nu15143123.
15. Lu K, Dong S, Wu X, Jin R, Chen H. Probiotics in cancer. Front Oncol. 2021;11:638148. doi: 10.3389/fonc.2021.638148.
16. Śliżewska K, Markowiak-Kopeć P, Śliżewska W. The role of probiotics in cancer prevention. Cancers (Basel). 2021;13(1):20. doi: 10.3390/cancers13010020.
17. Le Noci V, Guglielmetti S, Arioli S, Camisaschi C, Bianchi F, Sommariva M, et al. Modulation of pulmonary microbiota by antibiotic or probiotic aerosol therapy: a strategy to promote immunosurveillance against lung metastases. Cell Rep. 2018;24(13):3528-3538. doi: 10.1016/j.celrep.2018.08.090.
18. Ranji P, Agah S, Heydari Z, Rahmati-Yamchi M, Alizadeh AM. Effects of Lactobacillus acidophilus and Bifidobacterium bifidum probiotics on the serum biochemical parameters, and the vitamin D and leptin receptor genes in mice with colon cancer. Iran J Basic Med Sci. 2019;22(6):631-636. doi: 10.22038/ijbms.2019.30260.7298.
19. Szkaradkiewicz AK. Progress in studies on application of probiotics in dentistry. Dent Forum. 2015;43(1):55-60.
20. Szkaradkiewicz AK, Stopa J, Karpiński TM. Effect of oral administration involving a probiotic strain of Lactobacillus reuteri on pro-inflammatory cytokine response in patients with chronic periodontitis. Arch Immunol Ther Exp (Warsz). 2014;62(6):495-500. doi: 10.1007/s00005-014-0277-y.
21. Fyhrquist N, Muirhead G, Prast-Nielsen S, Jeanmougin M, Olah P, Skoog T, et al. Microbe-host interplay in atopic dermatitis and psoriasis. Nat Commun. 2019;10(1):4703. doi: 10.1038/s41467-019-12253-y.
22. D'Elios S, Trambusti I, Verduci E, Ferrante G, Rosati S, Marseglia GL, et al. Probiotics in the prevention and treatment of atopic dermatitis. Pediatr Allergy Immunol. 2020;31 Suppl 26:43-45. doi: 10.1111/pai.13364.
23. Shirkhan F, Safaei F, Mirdamadi S, Zandi M. The role of probiotics in skin care: advances, challenges, and future needs. Probiotics Antimicrob Proteins. 2024;16(6):2132-2149. doi: 10.1007/s12602-023-10174-3.
24. Vasam M, Korutla S, Bohara RA. Acne vulgaris: a review of the pathophysiology, treatment, and recent nanotechnology based advances. Biochem Biophys Rep. 2023;36:101578. doi: 10.1016/j.bbrep.2023.101578.
25. Deplewski D, Rosenfield RL. Role of hormones in pilosebaceous unit development. Endocr Rev. 2000;21(4):363-392. doi: 10.1210/edrv.21.4.0404.
26. Nickles MA, Sharma D, Tsoukas MM, Ashack KA. Acne and insulin resistance: a systematic review and meta-analysis. J Am Acad Dermatol. 2022;87(3):687-688. doi: 10.1016/j.jaad.2021.11.057.
27. Fabbrocini G, Bertona M, Picazo Ó, Pareja-Galeano H, Monfrecola G, Emanuele E. Supplementation with Lactobacillus rhamnosus SP1 normalises skin expression of genes implicated in insulin signalling and improves adult acne. Benef Microbes. 2016;7(5):625-630. doi: 10.3920/BM2015.0089.
28. Sutema IAMP, Latarissa IR, Widowati IGAR, Sartika CR, Ciptasari NWE, Lestari K. Efficacy of probiotic supplements and topical applications in the treatment of acne: a scoping review of current results. J Exp Pharmacol. 2025;17:1-14. doi: 10.2147/JEP.S498769.
29. Gether L, Overgaard LK, Egeberg A, Thyssen JP. Incidence and prevalence of rosacea: a systematic review and meta-analysis. Br J Dermatol. 2018;179(2):282-289. doi: 10.1111/bjd.16481.
30. Holmes AD. Potential role of microorganisms in the pathogenesis of rosacea. J Am Acad Dermatol. 2013;69(6):1025-1032. doi: 10.1016/j.jaad.2013.08.006.
31. Szkaradkiewicz A, Chudzicka-Strugała I, Karpiński TM, Goślińska-Pawłowska O, Tułecka T, Chudzicki W, et al. Bacillus oleronius and Demodex mite infestation in patients with chronic blepharitis. Clin Microbiol Infect. 2012;18(10):1020-1025. doi: 10.1111/j.1469-0691.2011.03704.x.
32. Manfredini M, Barbieri M, Milandri M, Longo C. Probiotics and diet in rosacea: current evidence and future perspectives. Biomolecules. 2025;15(3):411. doi: 10.3390/biom15030411.
33. Parodi A, Paolino S, Greco A, Drago F, Mansi C, Rebora A, et al. Small intestinal bacterial overgrowth in rosacea: clinical effectiveness of its eradication. Clin Gastroenterol Hepatol. 2008;6(7):759-764. doi: 10.1016/j.cgh.2008.02.054.
34. Armstrong AW, Read C. Pathophysiology, clinical presentation, and treatment of psoriasis: a review. JAMA. 2020;323(19):1945-1960. doi: 10.1001/jama.2020.4006.
35. Amalia N, Wicaksono D, Wiyarta E, Rampengan DDCH, Darmawan H, Aditya M, et al. The gut-skin axis in psoriasis: evidence-based insights from a meta-analysis on probiotics-synbiotics-mediated microbiota interventions. Med Microecol. 2025;24:100126. doi: 10.1016/j.medmic.2025.100126.

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